IMAGE PROCESSING APPARATUS AND METHOD

BACKGROUND OF THE INVENTION

The present invention relates to an image processing apparatus and method, or in particular to an image processing apparatus and method for generating a

5   monochromatic image of high resolution using the technique of pixel shift in a color imaging device having a plurality of two-dimensionally arranged photo detectors.

A solid state image sensing device such as

10 CCD has an imaging surface with a plurality of photo detectors two-dimensionally arranged thereon and forms an image of an object on the imaging surface thereof using an imaging optical system. The resolution of the imaging device is determined by the pitch at which the

15 photo detectors are arranged. For improving the resolution, therefore, the density with which the photo detectors are arranged is required to be increased. An increased density with which the photo detectors are arranged, however, both makes it more difficult to

20 fabricate the imaging device and increases the fabrica-
tion cost of the imaging device. Also, an increased density with which the photo detectors are arranged and the resultant reduced size of pixels decreases the sensitivity of the individual photo detectors, as a

25 result, the sensitivity of the imaging device is

decreased.

JP-A-10-304235 discloses a method of forming a color image using the technique of what is called "image shift", in which a plurality of images are picked up by shifting the imaging surface of a solid state image sensing device by a predetermined amount each time, and then a plurality of these images picked up are synthesized to generate a color image of high resolution.

Fig. 4 is a diagram showing a conventional method of acquiring a monochromatic image. A monochromatic image of high resolution can be acquired using a plurality of color images generated by the image shift technique. Fig. 4A is a diagram showing an array of color filters for the three primary colors of R, G, B arranged at positions corresponding to the photo detectors constituting the imaging surface of a color imaging device. This method of layout is known as the Bayer scheme. In the Bayer scheme, green (G) filters for the luminance signal requiring high resolution are arranged checkerwise, and the remaining filters including alternate groups of red (R) filters and blue (B) filters are arranged checkerwise. Thus, the green (G) filters are arranged with the density (resolution) of one half of all the photo detectors, and the red (R) and blue (B) filters with the density of one fourth of all the photo detectors.

In the prior art, three images having the

same resolution are generated for the colors R, G and
B.   Specifically, a plurality of image data are
acquired for each color by pixel shift in such a manner
as to assure the same level of the resolution as the
5   density of arrangement of the photo detectors for each
color. First, as for green (G), the image data is
acquired first from given relative positions of the
color imaging device and the object image, and then by
shifting the relative positions of the color imaging
10   device and the object image by a pitch of one pixel as
indicated by arrows in Fig. 4B. Only the green (G)
portions of the two image data thus acquired are
extracted thereby to generate a single image composed
of the green (G) portions. As for blue (B), on the
15   other hand, a total of four image data are acquired by
shifting the relative positions of the color imaging
device and the object image by a pitch of one pixel in
three different directions as indicated by arrows in
Fig. 4C, and then only the blue (B) portions of the
20   four image data thus acquired are extracted thereby to
generate a single image composed of the (B) portions.
In similar fashion, as for red (R), a total of four
images are acquired by shifting the relative positions
of the color imaging device and the object image by a
25   pitch of one pixel in three different directions as
indicated by arrows in Fig. 4C, and then only the red
(R) portions of the four acquired image data are
extracted thereby to generate a single image composed

of the (R) portions. The resolution of the mono-
chromatic images acquired as described above is twice
as high for green G and four times as high for blue B
and red R, so that the same resolution is secured for
5 R, G and B.

In the case where the relative positions of
the color imaging device and the object image are
shifted by a pitch of one half pixel, in contrast, the
image data can be acquired which has a density twice as
10 high as the density with which the photo detectors are
arranged for each color. Specifically, as for green
(G), as shown in Fig. 4D, eight image data having
different relative positions of the color imaging
device and the object image are acquired, and a single
15 image data having only the (G) portions is generated.
As for blue (B), on the other hand, as shown in Fig.
4E, sixteen image data having different relative
positions of the color imaging device and the object
image are acquired, and a single image data composed of
20 only the (B) portions is generated. In similar
fashion, as for red (R), as shown in Fig. 4E, sixteen
image data having different relative positions of the
color imaging device and the object image are acquired,
and a single image data composed of only the (R)
25 portions is generated. In this case, the resolution of
the monochromatic images is eight times as high for
green G and 16 times as high for blue B and red R.

A black-and-white monochromatic image is

generated by combining the high-resolution images of three colors RGB obtained by the image shift method described above. In this case, the images of R, G and B are generated to the same resolution. In generating

5 a black-and-white monochromatic image data by combining the three-color image data in the same position of the three images of R, G and B, calculations are carried out for each pixel taking the spectral sensitivity, the luminous efficacy, etc. of the color imaging device

10 into consideration, and after complete calculations for all the pixel data, the black-and-white monochromatic image is formed.

The generation of a black-and-white mono-chromatic image by this method requires the extra time

15 of calculations for the black-and-white monochromatic image data in addition to the time required for the generation of the monochromatic images of the three colors R, G and B, resulting in a longer time for generating a monochromatic image. In the technique of

20 shifting the image by a pitch of one half pixel described above, for example, the calculation time for synthesizing the black-and-white monochromatic image data is required in addition to the time of picking up the 16 images. Incidentally, since the 16 images are

25 picked up at the same time for the three colors at each position, the three-color monochromatic images can be acquired in the time required to pick up 16 images.

As described above, the additional calcula-

tion time for the generating a black-and-white mono-
chromatic image is required for the acquisition of a
three-color monochromatic image.

SUMMARY OF THE INVENTION

5   The object of the present invention is to
provide an image processing apparatus and method for
generating a monochromatic image of high resolution in
a short time using the image shift scheme.

         A black-and-white monochromatic image not
10   substantially deteriorated in image quality could be
acquired from an object image using only the green (G)
color most contributive to the luminance signal. This
was especially with the case with the operation of
reading a voucher or slip printed in black and white.
15   With a scanner, which generally reads a monochromatic
image of characters and diagrams plotted on the paper,
for example, there is no need of converting a color
image into an exact black-and-white monochromatic
image, but the only need is to generate a substantially
20   compatible monochromatic image. The present inventor
has empirically conceived this invention based on the
above-mentioned fact.

         According to the invention which has been
achieved in view of the points described above, there
25   is provided an image processing apparatus and method in
which a monochromatic image only of a color associated
with a filter having the highest pixel density is

acquired with high resolution using the image shift
scheme, and the image is processed with the particular
monochromatic image alone.

An image processing apparatus according to an
5   embodiment of the invention comprises an imaging
optical system for picking up an image of an object, a
color imaging device including a multiplicity of sets
of four filters for three colors one of which uses two
of the four filters, each filter being arranged at a
10   position of a corresponding pixel on the imaging
surface of the color imaging device, shift drive means
for shifting the imaging optical system and the color
imaging device relatively to each other by the length
corresponding to a predetermined number of pixels, and
15   a device for generating and outputting a monochromatic
image only from the pixel data of the same color for
different relative positions before and after the
shift.

BRIEF DESCRIPTION OF THE DRAWINGS
20   Fig. 1 is a block diagram showing an image
processing apparatus according to an embodiment of the
invention.

Figs. 2A, 2B and 2C are diagrams showing a
method of acquiring a monochromatic image according to
25   the invention.

Fig. 3 is a flowchart showing the steps of
the process for acquiring a monochromatic image accord-

ing to the invention.

Figs. 4A-4E are diagrams showing a conventional method of acquiring a monochromatic image.

DESCRIPTION OF THE INVENTION

5   An embodiment of the invention will be explained with reference to Figs. 1 to 3.

In Fig. 1, an imaging optical system 1 forms an object image on the imaging surface of a color imaging device 2. The color imaging device 2 spatially

10   samples the object image formed on the photo detectors arranged two-dimensionally on the imaging surface and, after photo-electric conversion, sends the signal to an output processing unit 5. The color imaging device 2 is preferably a solid state image sensing device such

15   as an area CCD for picking up a two-dimensional image.

Shift drive means 3 is adapted to shift the relative positions of the color imaging device 2 and the object image and thus move the color imaging device 2 on the image forming surface using electrical inching

20   means such as a piezoelectric device.

A control unit 4 moves the position of the color imaging device 2 to the next frame position having different relative positions by driving the shift means 3 while a frame of image data is being sent

25   from the color imaging device 2 to the output processing unit 5. Thus, the image data for the next frame is acquired. In this way, a plurality of image data

having different relative positions of the color
imaging device 2 and the object image are acquired, and
by interpolating adjacent pixel data, the resolution is
improved.

5   The output processing unit 5 amplifies each
analog image data sent from the color imaging device,
and by sampling the base line portion and the signal
portion alternately, performs the correlated double
sampling for detecting a signal representing the

10   difference between the base line portion and the signal
portion. After A/D conversion, digital image data are
output.

          An image synthesizing unit 6 generates a
single monochromatic image of an object of a higher

15   resolution by interpolating adjacent pixel data from a
plurality of image data having different relative
positions. The image is synthesized by interpolation,
i.e. by filling, in a single image data, the pixels
having no pixel data with corresponding pixel data of a

20   single image data at a different position. This
interpolation requires no special calculation which
takes each of the colors RGB into consideration.

          An image processing unit 7 performs the
shading correction for securing a uniform brightness

25   over the whole screen, the γ correction for regulating
the input/output characteristics, and the MTF correc-
tion for emphasizing the contour of the image. The
image processing unit 7 can also convert a three-color

image of RGB to a black-and-white monochromatic image
as required. Also, the image processing unit 7 can
select a color image or a monochromatic image of an
object in compliance with an instruction from the user.

5 An output unit 8 produces the synthesized image data
from the image processing unit 7 on an output line 9 in
a format suitable for the protocol of an external
interface.

Figs. 2A, 2B and 2C are diagrams showing a

10 method of acquiring a monochromatic image. For acquir-
ing a monochromatic image, first, a plurality of color
images of a specified color are generated by the pixel
shift method. A monochromatic image of high resolution
can be acquired using the color images thus generated.

15 Fig. 2A is a diagram showing a color filter array of
the aforementioned Bayer scheme which is formed on the
imaging surface of the color imaging device. As
described above, according to the Bayer scheme, green
(G) filters for the luminance signal requiring a high

20 resolution are arranged checkerwise with a density one
half that of the photo detectors, while red (R) and
blue (B) filters are arranged with a density of one
fourth that of the photo detectors. As a color of the
image data acquired by pixel shift, green (G) is

25 selected. A plurality of image data of this color are
acquired and synthesized into a single green (G) mono-
chromatic image.

Specifically, the image data of green (G) is

acquired at certain positions of the color imaging

device and the object image. Then, the image data is

acquired by shifting the relative positions of the

color imaging device and the object image by a pitch of

5 one pixel as indicated by arrows in Fig. 2B. The green

(G) portions of the two image data thus acquired are

extracted, and by interpolating the pixels lacking the

pixel data of G in one image with the pixel data of the

other image, a single monochromatic image of green (G)

10 is produced by synthesis.

Fig. 3 is a flowchart showing the operation

of the control unit 3 for performing the process of

acquiring the monochromatic image. In step 1, an

object image is picked up. In step 2, the green (G)

15 portions of the image picked up are extracted. In step

3, the relative positions of the color imaging device

and the object image are shifted by, say, one pitch as

shown in Fig. 2B. In step 4, the object image is

picked up. In step 5, the green (G) portions of the

20 image picked up are extracted. In step 6, the green

(G) portions of the images extracted in steps 2 and 5

are synthesized. In step 7, the synthesized image is

corrected variously thereby to generate a monochromatic

image. In step 8, the monochromatic image is output to

25 an external circuit. As described later, steps 3 to 5

are repeated a predetermined number of times in the

case where the pixel shift is set to one half pitch.

For acquiring the monochromatic image of blue

(B), on the other hand, the relative positions of the color imaging device and the object image are shifted by a pitch of one pixel in three different directions as indicated by arrows in Fig. 4C to acquire four image

5   data, after which the blue (B) portions of the four image data thus acquired are extracted thereby to synthesize a blue (B) monochromatic image. In similar fashion, the monochromatic image of red (R) can be acquired in the following way. The relative positions

10 of the color imaging device and the object image are shifted by a pitch of one pixel in three different directions as indicated by arrows in Fig. 4C to acquire four image data, after which the red portions (R) of the four image data thus acquired are extracted to

15 synthesize a red (R) monochromatic image. These opera-tions for blue (B) and red (R) are not always necessary but can be carried out selectively as required.

In the case where the relative positions of the color imaging device and the object image are

20 shifted by a pitch of one half pixel, the image data having a density twice as high as the density at which the photo detectors are arranged can be acquired for each color.

Specifically, as for green (G), as shown in

25 Fig. 2C, eight image data having different relative positions of the color imaging device and the object image are acquired, and by extracting the green (G) portions of the eight image data thus acquired, a

single green (G) monochromatic image can be synthe-
sized.

For acquiring the monochromatic image of blue
(B), on the other hand, as shown in Fig. 4E, sixteen
image data having different relative positions of the
color imaging device and the object image are acquired,
and by extracting the blue (B) portions of the sixteen
image data thus acquired, a single blue (B) mono-
chromatic image can be synthesized. In similar
fashion, for acquiring the monochromatic image of red
(R), as shown in Fig. 4E, sixteen image data having
different relative positions of the color imaging
device and the object image are acquired, and by
extracting the red (R) portions of the sixteen image
data thus acquired, a single red (R) monochromatic
image can be synthesized.

In the Bayer scheme, the green (G) filters
are arranged with a density twice as high as the blue
(B) filters or the red (R) filters. Specifically,
although eight green (G) images are picked up, sixteen
images are picked up for blue (B) and red (R), respec-
tively. In the case where a monochromatic image of
only green (G) is acquired with an increased density,
therefore, the number of images picked up is one half
of those for blue (B) or red (R). Thus, the time
required for imaging is also reduced to one half for
green (G). Further, since no additional calculation
time is required, the time for picking up only eight

images is required to generate a monochromatic image of green (G). In this way, according to this embodiment of the invention, the time required for generating a monochromatic image can be shortened to one half or
5 less of the time conventionally required.

As described above, a satisfactory mono-chromatic image can be acquired using only green (G) color to which the luminance signal contributes in a higher ratio, except in the case where the object to be
10 read belongs to the green group as a whole. Especially when reading vouchers or slips printed in black and white, the image quality is not deteriorated.

The foregoing description concerns an example in which the amount of pixel shift is set to a pitch of
15 1/2 pixel. However, the same principle is applicable also to the amount of pixel shift at a pitch of 1/n pixel. The time shortened for acquiring a mono-chromatic image is increased in proportion to n.

Apart from the Bayer scheme used for arrang-
20 ing primary-color filters of the color imaging device, a monochromatic image can be generated also by other methods of arrangement using the output of the photo detectors having filters of a color with the largest occupancy rate of the light receiving surface. Also,
25 complementary color filters (Ye, Mg, Cy) can be used for the filters described above.